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Abstract

THERMAL REACTOR PHYSICS STUDIES ON PLUTONIUM FUELS

by

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Results of experimental measurements on a range of plutonium-fuelled, water and graphite moderated subcritical and critical assemblies are described and compared with calculations using multigroup diffusion and transport theory methods.

Brief accounts are given of the equipment, fuel elements and experimental techniques. Bucklings of assemblies fuelled with thin plutonium aluminium alloy plates, and with plutonium-uranium alloy bars have been determined by the exponential method. Relative reaction rates of various nuclides have been measured in these assemblies to provide a check on accuracy of spectrum calculations. Experiments on a plutonium-fuelled graphite moderated critical assembly have been carried out to obtain temperature coefficients of reactivity and power distributions. A direct measurement of the neutron energy spectrum in this system has been made by the time-of-flight technique.

A new 40-group scheme of calculation based on the Winfrith DSN code is described. A discussion of the basic nuclear data for fuel and moderator used in this scheme is given.

The agreement achieved between theoretical prediction and experimentally determined reactivity, temperature coefficients, reaction rates and neutron energy spectra is discussed, and compared with that found for similar uranium-fuelled systems.

Conclusions are presented concerning the adequacy of the theoretical methods and nuclear data, and proposed extensions of the theoretical and experimental work to further systems is described.

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Abstract

FAST REACTOR PHYSICS, INCLUDING RESULTS FROM U.K. ZERO POWER REACTORS

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The nuclear data needed for fast reactor calculations covers a wide energy range and present measurements are not sufficiently comprehensive and accurate to be used as the sole basis for calculation. Thus the calculations for fast reactors commonly use sets of data in a number of energy groups in which the contents have been selected or adjusted as a result of measurements on zero power reactors. The sets used are reviewed and their defects discussed. A new approach using GALAXY and the Data File has been developed in the U.K. which approaches the ideal of calculations based solely on basic nuclear data.

Calculations for fast reactors use a number of well-proved transport and diffusion theory codes, which can be used with up to about 30 groups in one or two dimensions. These calculations give the spectrum above about 50 Kev fairly well. Problems arise in extending these calculations to three dimensions and in covering the region from 50 KeV to 50 eV where resonance effects are

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important. This energy region is of vital interest in the calculation of sodium and Doppler temperature and power coefficients.

The dynamic behaviour of the reactor and the control system used depends on the values of these power and temperature coefficients, though it is possible to design an entirely satisfactory control system even with unfavourable power coefficients.

A more stringent limitation on possible values of temperature coefficients arises in the study of reactor accidents. The types of accident that need to be studied are reviewed and their interpretation with the reactivity coefficients considered. These accidents include coolant flow failure, accidental ramp or step reactivity additions. The reliability of present methods of calculating the dynamic behaviour of a reactor is considered in the light of the agreement between calculation and experiment on the D.F.R. These methods are used to predict the behaviour of a large power fast reactor, and the importance of the Doppler temperature coefficient of reactivity demonstrated.

The Doppler effect also has a profound influence in the case of the hypothetical accident resulting from the melt-down of a fast reactor core and leading to the formation of a super-prompt critical assembly. It is shown that a relatively small Doppler coefficient will reduce the energy yield in the resulting power excursion by a large factor.

In order to fix the design of a power reactor it is necessary to make a choice out of a large number of variable design parameters. To make a systematic choice possible a computer programme has been written to enable the effects of variation in a basic design to be assessed rapidly. The capabilities of this programme are discussed and some results of the survey are presented.

The data and calculation methods used in the design of the P.F.R. are being checked against measurements made in zero-power assemblies. Results from Vera, Zebra and Quagga are quoted and the choice of assemblies to emphasise particular nuclear data discussed. The experimental results are then compared with the theoretical predictions for critical mass, spectrum and reaction rates and the observed discrepancies discussed. The prediction of the Doppler coefficient of a power reactor can be improved by measurements made in a zero power reactor - and several experiments are planned.